visible region by chlorophyll is not sufficient to induce the complete reaction, since 150,000 calories per gram-molecule is almost exactly one quantum per molecule at $\lambda=200\mu\mu$. Certain quantitative experiments have shown that a possible explanation of this is to be found in the fact that the carbonic acid is partly activated by combination with the chlorophyll. Alternatively, it is possible that, whilst one quantum of energy at $\lambda=200\mu\mu$ is required for the complete reaction with the escape of free oxygen, one quantum of visible light as absorbed by the chlorophyll is sufficient to induce the reaction

$$\text{Chlorophyll A}+H_2CO_3=\text{chlorophyll B}+CH_2O.$$

It is scarcely necessary to point out that either of these alternatives amplifies the principle of photocatalysis as previously defined. In either case the completion of the reaction, whereby the oxygen is abstracted from the chlorophyll B and transpired into the atmosphere, must require a further supply of energy. This second amount of energy is doubtless absorbed by the carotin and xanthophyll, the absorption bands of which lie in the visible region and between those of chlorophyll, so that each can absorb visible light simultaneously and independently. This suggested explanation is now being investigated.

Reference may be made to some other work now in progress at Liverpool which has already given most promising and suggestive results. By the action of ultra-violet light on aqueous solutions of formaldehyde, several hundred grams of concentrated sugar syrup have been prepared. Analysis of this syrup has shown that the sole products of the polymerisation are hexoses, no trace of a triose or pentose having been found. This result is very striking in view of the greater possibility on the kinetic theory of the formation of sugars containing fewer than six carbon atoms. There can therefore be no possible doubt that the sole products of the polymerisation of the activated formaldehyde as photosynthetically produced in the living plant are also hexoses. Not only does this afford a ready explanation of the storage of starch in the chloroplast during the period of photosynthetic activity and its subsequent hydrolysis to hexoses, which are utilised by the plant in later syntheses, but it also establishes the fact that pentoses must be formed from hexoses, possibly through furane compounds; further, it opens the door to most promising theories of the synthesis of other plant products, every stage of which is attractive in its simplicity.

Then, again, there is the question of the production of the various nitrogen compounds in the plant, which is one of considerable interest, since it would seem that the principal source from which the plant derives its nitrogen is potassium nitrate. It is well known that metallic nitrates are readily converted to nitrites by material catalysts as well as by ultra-violet light. Baudisch has shown that an aqueous solution of potassium nitrite and methyl alcohol, on exposure to ultra-violet light, gives formhydroxamic acid, the alcohol first being converted to formaldehyde. This has been confirmed at Liverpool by investigation of the action of ultra-violet light on aqueous solutions of potassium nitrate or nitrite containing formaldehyde, and it has been proved that an activated molecule of formaldehyde combines with a molecule of potassium nitrite according to the equation $CH_2O+KNO_2=CH(OH){:}NOK+O$, since the reaction takes place only in the light. It has also been found that if the activated formaldehyde is in excess formhydroxamic acid and hexoses are simultaneously and independently produced. This condition is doubtless that which obtains in the plant, and it may be concluded that the two syntheses take place in the leaf without mutual influence. It is worthy of note that the photosynthesis of formaldehyde and the synthesis of formhydroxamic acid are both accompanied by the setting free of oxygen.

Experiments are also in progress on the reaction between activated formaldehyde and ammonia, and although these are not yet complete, they have already established the great reactivity of activated formaldehyde towards ammonia. Whatever, therefore, may be the starting point on the nitrogen side, potassium nitrate or ammonia, there is no question that, in the presence of activated formaldehyde such as is produced photosynthetically in the plant, compounds are formed in which carbon and nitrogen are united, thus securing the first step towards protein, pyrrole, and alkaloid synthesis.

Finally, one very important deduction may be made. The sole photosynthetic process in the living plant would seem to be the production of activated formaldehyde from carbon dioxide and water. These activated molecules either polymerise to hexoses or react with potassium nitrite or ammonia. Any further reactions are not photochemical except in so far that the first synthesised nitrogen compounds combine with more molecules of activated formaldehyde to give complex nitrogen derivatives.

The Migration of British Swallows.

By Dr. A. LANDSBOROUGH THOMSON, O.B.E.

> "Sister, my sister, O fleet sweet swallow,
> Thy way is long to the sun and the south."
> SWINBURNE.

FROM time immemorial the Swallow (*Hirundo rustica*, Linn.) has been a proverbial type of summer visitor to our northern lands, but age-long familiarity with the fact of its seasonal appearance and disappearance has not served to bring us complete knowledge or understanding: there are many secrets, both matters of fact and questions of interpretation, to which we have as yet no clue. Nevertheless we are in a better position to appreciate the problem than were Gilbert White and his contemporaries, who were obsessed with the idea that hibernation, particularly in regard to this species, might play an important part as an alternative to migration. White was particularly influenced by the frequent phenomenon of the few "early swallows" which appear some time before the main contingents arrive, and are no more seen if wintry weather should recur in the meantime. The theory of hibernation dies hard even to-day, and every now and then some imperfect piece of evidence in its favour is recorded—cases, for instance, of birds lingering in autumn being overtaken by hard weather and being found in a comatose condition, really moribund rather than dormant. The further idea that the place of hibernation was in the mud at the bottom of reedy ponds was regarded with sufficient seriousness in the time of John Hunter, the famous anatomist, for him to examine it scientifically; with a truly modern appreciation of experimental methods, he confined swallows in a conservatory one autumn, providing them with water, reeds, and mud, and the result naturally confirmed his scepticism.

Nowadays we know enough of migration to have no need to explore alternative theories, but it still remains true that we see migration actually in progress comparatively seldom, although perhaps we do so more often in the case of swallows than in that of most small birds. The writer recalls one fortunate occasion, for example, when he spent the morning of a bright autumn day sitting at the extreme northern apex of the isle of Heligoland watching the swallows coming in over the sea in the teeth of a southerly gale. For hours there was a steady succession of small bands of from half-a-dozen to a score of swallows, all flying low over the sea and coming into sight as they rose to the level of the cliff-tops. All the birds kept to the same course, the stream following the line of the western cliffs and quitting the island again at its south-western corner. Only an occasional bird circled round for a few minutes, and none seemed inclined to break its journey so early in the day in spite of the adverse conditions. But a glimpse of this kind is only seeing in momentary cross-section, so to speak, one tiny rivulet of the great emigratory stream of swallows from Northern Europe.

Much has been learnt, however, by the careful piecing together of observations collected from many different places, notably from the lighthouses and lightships round the British coasts. From these data Dr. Eagle Clarke was able to give us some years ago, in the report of the special committee appointed by the British Association, an elaborate summary of the movements which usually take place in the British area, and more recently this has been supplemented by the labours of a committee of the British Ornithologists' Club. A few early birds may appear in March, but the average times for the arrival of the vanguard of our summer visitant swallows are:—for south-western England the beginning of the first week in April, for Ireland the end of that week, for south-eastern England early in the second week, for south-western Scotland the end of the same, for south-eastern Scotland the middle of the third week, for northern Scotland the fourth week, and for the Orkney Isles the second week of the following month; the main influx usually begins some ten or twelve days later in each case. The earlier dates for the western regions, latitude being equal, are noteworthy, and it appears that the immigratory waves arrive along the whole length of the south coast of England, but first and chiefly on its western half. Before this immigration of our native birds has been completed—at the very end of April—there begin the passage movements of swallows traversing the eastern seaboard of Great Britain *en route* for northern Europe, and these movements may be prolonged until almost the middle of June.

Decided southerly movements within the British area begin towards the end of August, and early in September actual cross-channel emigration sets in and continues for nearly two months, after which only stragglers are as a rule recorded. From the middle of September onwards there is also the return passage of swallows from Northern Europe, and the two sets of movements are not easily distinguishable. There is also a passage movement from Central Europe, first observed by Dr. Eagle Clarke from the Kentish Knock Lightship, the line of flight being roughly from east to west; the existence of a corresponding spring passage on this line has not been definitely established. A very few instances are on record of swallows surviving in this country throughout exceptionally mild winters.

Within the last few years the method of marking birds with numbered aluminium rings has been widely employed in this country, under the auspices both of the magazine *British Birds*, edited by Mr. H. F. Witherby, and of the University of Aberdeen. The proportion of marked swallows recovered is unfortunately very small, for out of 1198 marked during the Aberdeen scheme only five, or 0.4 per cent., were recovered. The *British Birds* scheme, which is still actively in progress, has nevertheless yielded a very interesting series of records for the species, representing a vast amount of energy in marking; 7597 had been marked up to the end of 1920, and 60 (or 0.7 per cent.) have been recovered. A brief summary of the results of this work, taking the published data of the two schemes together, may accordingly be given with advantage.

There are, to begin with, various records of swallows marked as nestlings and recovered within a few miles a little later in the same season, but these are without special significance. The European stages of migration are indicated by records of birds marked as nestlings and reported in their first year, as follows: one marked in Lancashire from the Isle of Wight late in October; one marked in Lancashire from Indre-et-Loire, in the centre of France, in September; one marked in Staffordshire from Charente-Inférieur, south-western France, in October; and one marked in Staffordshire from Brittany in December, but without information as to how long it may have been lying dead before it was discovered. Further, a swallow marked as a nestling in Staffordshire was recovered at Bilbao, northern Spain, in March of the following year.

Four swallows marked as nestlings, all under the *British Birds* scheme, have been recovered in South Africa during their first winter: a Lancashire bird in Cape Province in February, an Ayrshire bird in the Orange Free State in March, a Yorkshire bird in East Griqualand in February, and a Stirlingshire bird in the Transvaal in January. A swallow marked in Staffordshire as an adult, also, was recovered in Natal in December of the second winter thereafter. Mr. Witherby has directed attention to the suggestive fact that all these five records of his are from the eastern portion of South Africa. A swallow marked in Schleswig-Holstein was obtained on migration at Bregenz, on the Lake of Constance; another, marked as a nestling in Overijsel, Holland, was recovered on October 1 of the same year at Tangier, Morocco.

Of great interest, also, are the records which indicate the return of swallows to their native districts in subsequent summers. Seventeen marked as nestlings have been so recorded, sixteen in the following summer and one in summer two years after marking, the localities ranging from Hampshire to Kincardineshire. Six marked as adults have been similarly recorded, three after one year and three after two years, the localities ranging from Staffordshire to Peeblesshire.

In some of the foregoing cases the return to the same place was very exact—even to the self-same porch or outhouse. In others the place of recovery was a few miles from the place of marking; a swallow marked as a nestling at Beaulieu (Hampshire), for instance, was recovered in the following May at Ringwood, in the same county but 18 miles distant. There are other cases, still to be mentioned, in which swallows marked as nestlings returned in the following summer to parts of the country rather more widely separated from their respective birthplaces, the distances being from Hampshire to Sussex (30 miles), from Hampshire to Middlesex (70 miles), from Stirlingshire to Yorkshire (170 miles), and from County Kildare to County Armagh (75 miles).

Migration of swallows from Great Britain to South Africa is thus clearly established, and it is also now certain that the birds commonly return to the same summer quarters, often with great exactness, in subsequent years. Much still remains to be learnt, and some of this the marking method may give us in time. What route is followed between Great Britain and South Africa, for example, and are the identical winter quarters repeatedly sought out in the same way as breeding-places? Further, how do the migrations of British swallows compare with those of swallows native to other countries: can we, for instance, confirm Dr. Hartert's suggestion that "the most northerly dwellers migrate furthest south, while the breeding birds of the Atlas Mountains probably go only to the oases of the Sahara for the winter"? These questions strike at the very roots of the nature of the migratory instinct, one of the great wonders of the animate world.

Obituary.

Prof. Benjamin Moore, F.R.S.

By the death of Prof. Benjamin Moore, at fifty-five years of age, science has suffered the loss of an original and daring thinker. Moore was born, and studied, in Belfast, and the first degree he took was Bachelor of Engineering. At one time he thought of following that profession. He received a travelling research scholarship, and studied physical chemistry under Ostwald in Germany, and then came to London and studied physiology under Sharpey Schafer. From thence he went to fill a chair at Yale Medical College, but returned a few years later to be lecturer in physiology at Charing Cross Medical School, and at the same time to qualify himself as a medical man—a double task requiring much nerve, energy and courage. Moore was then elected to the newly-founded Johnston chair of biochemistry at Liverpool—the first chair in that subject to be founded in this country. He took a most active share in the development of the Medical School at Liverpool University, and jointly with Mr. Whitley founded the *Biochemical Journal.* He was elected a Fellow of the Royal Society in 1912. In 1914 he accepted an invitation to join the Department of Applied Physiology under the Medical Research Council, and after rendering valuable services to industrial medicine during the War, was elected, in 1918, to the newly-founded Whitley chair of biochemistry at Oxford. There he quickly inspired several of his honour school students to carry out pieces of research work, and all too soon he has passed from thence, the victim of influenza. He took the greatest interest in Public Health, and a State Medical Service, as shown by his book "The Dawn of the Health Age."

Moore was a man of impetuous imagination, conceiving brilliant ideas, and stimulating others by these and his enthusiasm; he was impatient under the necessarily slow accumulation of results required for confirming his ideas—an impatience which sometimes led him to be too hasty in publication, and to subject himself to criticism whereby his spirit was vexed and his energy wasted in controversy. He was perhaps sometimes wild, sometimes wrong, but often the pioneer in visions of great value. To him we owe the first attempts in this country to apply the results of physical chemistry to the intricate problems of biology. The article by Moore published in "Recent Advances in Physiology," edited by L. Hill, and last year elaborated and republished in book form, did much to found the British school of physico-chemical physiology.

Moore was fascinated by the problem of the origin of life, and formed conceptions of the first steps in the evolution of life by the synthesis of inorganic compounds. He was able to show the formation of formaldehyde from CO_2 and H_2O under the influence of sunlight on a commonly occurring substance like iron oxide. This was the beginning of a series of papers on photosynthesis, on which a value higher than at present will probably be set in future time. He recently demonstrated the production in the air of oxides of nitrogen by the action of sunlight, and conceived the assimilation of these when dissolved in rain and dew by the green leaf. He was a pioneer in the work which is now given so much attention among physiologists, namely, on the normal reaction of body fluids and the maintenance of this normality, acidosis, etc.

Tackling the problem of trinitrotoluene poisoning, which was working havoc in munition factories during the War, Moore found that the chief danger was due to the absorption of this material through the skin—a view which met with considerable opposition, and led to controversial strain upon his sensitive nature. This discovery, when fully accepted, enabled thousands of workers to be preserved from poisoning during the War, and saved the country paying out hundreds of thousands of pounds in the settlement of employers' liabilities.

The sudden death, from appendicitis, of Moore's wife, who was devoted to his care, was an irreparable loss to him, and made a vast difference to the happiness and health of his last years. He leaves one son—a chemist in training—and two daughters.

L. H.

Dr. A. D. Waller.

We record with much regret the death on March 11, at fifty-five years of age, of Dr. A. D. Waller, director of the physiological laboratory and professor of physiology in the University of London.